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IMAGE ANALYSIS PROGRAM

13 March 1968

NPIC/TSSG/DED

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FOREWORD

In going over the memorandum which follows, the reader will find it useful to have in mind these definitions:

Microdensitometry - Density is roughly equivalent to the darkness of photographs, and a densitometer is an instrument for measuring that darkness. But, since the overall density of photographic images depends on the number of individual microscopic silver grains per unit area, a microdensitometer is used for detailed study of image quality. This device, which consists of lenses, a light-sensitive electronic detector (photo cell), and a recording pen, detects and records density differences much smaller than the human eye can notice. In addition to scientific analyses of image quality, the microdensitometer is used in efforts to enhance imagery so as to extract more information from it. One of the most frequent additional uses of the microdensitometer is for measuring exact distances on photography. The changes in density on the chart drawn by the microdensitometer recording pen often show the boundaries of objects more clearly, so measurements can be made on the chart rather than on the photograph.

Coherence - As related to the Image Analysis Program. Natural illumination is a rabble army of light waves jumbling along out-of-step, bumping into one another, stumbling over some obstacles, and bouncing back from others. However, the very randomness of this incoherent illumination makes it useful for viewing photographic imagery. This is because the variations among the waves tend to average out, giving a statistically uniform light like a crowd moving through Times Square on New Year's Eve.

Pure illumination, as from a laser, is a drill team of light waves marching in lockstep, every shoe hitting the road together (this is called being in phase), and every stride the same length (that is, of the same frequency). Thus, when any wave encounters an obstacle it bounces back (reflects) or deviates from its path (refracts), and creates noticeable disturbance patterns (interference) in the otherwise well ordered illumination. Therefore, this pure, coherent light is unsuitable for viewing imagery; there is no random compensation, so the imagery appears with spurious blank spots, circles and lines caused by the light waves interfering with each other.

Those two cases are fairly clear cut, but trouble arises when a few waves happen to be in step in an otherwise random illumination. This state of partial coherence cannot be readily detected and a person viewing the imagery might be badly misled by the distortions and spurious images resulting from an inappropriate light source. Furthermore, certain conditions in viewing transparencies can sometimes create partial coherence in otherwise incoherent illumination.

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PPB 68-0170

NPIC/D-50-68

18 MAR 1968

Executive Registry
68-1690

MEMORANDUM FOR: Deputy Director of Central Intelligence

THROUGH : Executive Director-Comptroller

Director, Office of Planning, Programming and Budgeting

Deputy Director for Intelligence

SUBJECT : Proposed Contract with [redacted] for Image Analysis

25X1

1. This memorandum requests approval for the commitment of funds for a follow-on R&D contract. The specific request is stated in Paragraph 7.

2. In recent years, vastly improved films and camera systems have increased the resolution of reconnaissance imagery, but development of equipment for exploiting the imagery has advanced at a much slower rate. This is because our incomplete understanding of the fundamental nature of high resolution photographic imagery makes it impossible to simply extend existing equipment design criteria to cover future exploitation equipment. The Image Analysis Program is an effort to close the knowledge gap that has thus grown between the photographic reconnaissance acquisition and exploitation technologies.

3. In FY 1966, a 5-year Image Analysis Program was initiated to investigate the nature of the photographic image and its interaction with equipment being used to reproduce and to view it. The main purpose of the first year's effort was to lay a strong technological base for subsequent experimental studies on operational films and equipment; these studies began in FY 1967. As a direct result of these investigations, a number of areas which promised significant potential equipment design improvements were isolated. During these first two years, an Isodensitracer (a special type of microdensitometer) was modified to provide contour drawings at high speeds. The present isodensitracers, while slow, have demonstrated capabilities as analytical tools for determining more precisely shapes and dimensions of objects indistinct on photography. The feasibility of "shaded apertures" has been demonstrated for a particular application and this technique is in the process of being refined. (A shaded aperture is a specially shaped opening in the objective lens component which modifies the light coming from the materials being studied.) The possibility of adapting the technique to microscopes is being

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SUBJECT: Proposed Contract with [redacted] 25X1
for Image Analysis

assessed. Techniques for readily measuring the degree of coherence in operational equipment have been developed. Finally, studies have been made to define the predictable mensuration errors due to film characteristics. It is proposed that the FY 1968 effort be directed toward completing the determination of the applicability of these promising areas to NPIC's equipment design criteria.

4. The basic tasks proposed to be studied under the FY 1968 contract are: (1) partial coherence, (2) shaded apertures, (3) microdensitometric analysis, and (4) film characteristics. Each of these is discussed briefly below:

a. Partial Coherence: [redacted] The illumination of any 25X1
viewing device is partially optically coherent. This means that when small details on a photograph are observed through such a device there are changes in the apparent image size and configuration. This, of course, can lead to errors in mensuration. The previous effort has provided the theoretical base necessary to evaluate this effect and has developed the tools with which to measure it. The work proposed is to determine that amount of coherence permissible in a system before significant distortion of the image occurs. This will provide criteria for the evaluation of existing equipment and for generating specifications for new equipment.

b. Shaded Apertures: [redacted] When the resolution of a 25X1
photographic image approaches the size of the light sensitive grains on the film, the grain begins to obscure information. Photo-optical technology has progressed to the stage where this is happening. A shaded aperture technique to suppress the grain without suppressing information was developed under the FY 1967 Image Analysis Program. This reduces the obscuring effect of the grain and increases the effective information content. A prototype aperture has been fabricated and a significant improvement has been demonstrated in laboratory microdensitometer applications, but the technique needs further testing in order to perfect it for more general application to NPIC's equipment. This contract will complete this testing and investigate the feasibility of using such an aperture in direct viewing equipment, such as microscopes.

c. Microdensitometry: [redacted] Microdensitometric evaluation 25X1
using an isodensity contour mode has proven itself to be an extremely useful tool for imagery exploitation; however, there are at least two drawbacks to this method: (1) it is slow and (2) in most cases it is difficult, if not impossible, to know in advance whether such an

SUBJECT: Proposed Contract with [redacted] for Image Analysis 25X1

evaluation will lead to any information gain for a particular piece of imagery. To solve the first of these problems, a high speed isodensity tracer called the Image Quantizer has been modified to handle reconnaissance imagery and will be delivered and evaluated during the proposed contract. To solve the second difficulty, an attempt will be made to develop objective criteria for determining when the microdensitometric techniques should or should not be utilized and to optimize the method. The latter consideration will be especially important with the introduction of the shaded aperture to the system.

d. Film Characteristics: [redacted] A thorough knowledge 25X1
of the basic characteristics of high-resolution photographic images is required by the Center. Presently this knowledge is still incomplete and this lack of understanding can lead to errors in mensuration for very small objects and makes the detailed analysis of such objects difficult or impossible. The FY 1967 Program investigated the effect of film and image characteristics on mensuration as performed on the original negative, and was able to correlate such characteristics in such a manner that the errors could be better defined and as a consequence, largely removed. The effect of this work will be to extend to even smaller dimensions that category of image detail upon which meaningful mensuration can be performed. For FY 1968 this work will be continued for first generation duplicate positives - the copy routinely used for analysis - and an attempt will be undertaken to develop an adequate mathematical model to predict these effects so that they can be compensated for mathematically.

e. Support: ([redacted] Besides these major areas, the 25X1
contractor will provide consultation and expert technical assistance on problems that arise in the general category of photographic technology. The empahsis in these support tasks will be in the area of photo and emulsion chemistry which have been performed in the past by contractors, but in the future will be performed in-house. During the transfer period it is necessary to use contractor personnel as consultants to provide complete continuity.

5. Because of the previous contracts and the special security problems involved, the Contracting Officer will be requested to award this contract on a sole source basis. There will be one significant subcontractor - [redacted] 25X1

6. This project has been coordinated with DDS&T and COMIREX and

R & D CATALOG FORM

DATE: 29 January 1968

1. PROJECT TITLE/CODE NAME: Image Analysis Study

2. SHORT PROJECT DESCRIPTION: The third year follow-on program of research into the concepts of image analysis.

3. CONTRACTOR NAME:

4. LOCATION OF CONTRACTOR: 25X1

5. CLASS OF CONTRACTOR: Research Laboratory (Commercial)

6. TYPE OF CONTRACT: CPPF

7. FUNDS
FY 1967 $
FY 1968 $
FY 1969 $

8. REQUISITION NO.: NA

9. BUDGET PROJECT NO.: 25X1 NP-A-1-04018

10. EFFECTIVE CONTRACT DATE (Begin - end): March 1968 - February 1969

11. SECURITY CLASS.
A.A. - Secret
T. - Unclassified
W. - Secret

12. RESPONSIBLE DIRECTORATE/OFFICE/PROJECT OFFICER TELEPHONE EXTENSION: DDI/NPIC/TDS 25X1

13. REQUIREMENT/AUTHORITY: Thorough evaluation and exploitation of contemporary and oncoming imagery requires information about the basic processes which is not now available. This study is essential to provide a basis for evaluation, interpretation, and communication in the field of image analysis.

14. TYPE OF WORK TO BE DONE: Applied research and experimentation, including a comprehensive review of available literature, in the nature of photographic and other images.

15. CATEGORIES OF EFFORT

MAJOR CATEGORY	SUB-CATEGORIES
Image Analysis Program	Optical Systems

16. END ITEM OR SERVICES FROM THIS CONTRACT/IMPROVEMENT OVER CURRENT SYSTEM, EQUIPMENT, ETC.: Reports on the basic nature and parameters of photographic and other images, including rigorous descriptions of image forming and recording processes and means of compensating for degradation caused by acquisition, reproduction, transmission, and viewing.

17. SUPPORTING OR RELATED CONTRACTS (Agency & Other)/COORDINATION: Basic coordination was accomplished with DD/S&T/ORD and with offices of DOD during the first phase, community coordination has been maintained on an informal and continual basis through EXRAND, SAFSS and SASPPF and by related briefings.

18. DESCRIPTION OF INTELLIGENCE REQUIREMENT AND DETAILED TECHNICAL DESCRIPTION OF PROJECT (Continue on additional page if required): Information from this study will help extract more intelligence from imagery, to deal with the increasing varieties of imagery available and to reduce available information into a form acceptable to computers for calculations and storage. Tasks under this project include studies in optics, photographic processes, the imaging properties of photographic material, systems performance, the physics of partially coherent photometry, and microdensitometers.

19. APPROVED BY AND DATE

OFFICE	DEPUTY DIRECTOR	DDCI

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